**Protocol for assigning credits for phosphorus and total suspended solids (TSS) for manufactured treatment devices**

**January 25, 2022**

This document defines MPCA protocol for determining total suspended solid (TSS) and phosphorus removal credits for manufactured treatment devices (mtds, also referred to as devices). See the section [**Protocol for determining credits**](#Protocol_for_determining_credits) for a description of which devices qualify for credits.

**Definition of credits**

In the context of an mtd, credit refers to the percent removal of total suspended solids (TSS) or phosphorus for runoff captured and treated by the device. As discussed in [the mtd monitoring protocol](https://stormwater.pca.state.mn.us/index.php?title=TP_and_TSS_credits_and_guidance_for_manufactured_treatment_devices_(mtds)#Protocol_for_monitoring), this discussion of credits applies only to water captured and treated by the device and does not include other practices in a treatment train, including pretreatment upstream of the mtd. It does not represent the total pollutant removal on an annual or event basis nor does it represent the mass of pollutant removed. These can be calculated as follows.

1. Removal on an annual or event basis = mtd removal efficiency \* percent volume captured and treated on an event or annual basis. For example, if a device removes 80% of TSS it captures and the device captures 90% of annual runoff, the device removes (0.8 X 0.9) or 72% of TSS on an annual basis.
2. Mass removed = mean concentration entering the device \* volume entering and treated by the device X removal efficiency. For example, if the mean concentration is 1 mg/L, one liter of runoff enters the device, and the device removes 80% of the pollutants, the mass removed is 0.8 mg.

**Purpose of this protocol**

# This protocol is used by Minnesota Pollution Control Agency (MPCA) staff to develop credits for mtds. The MPCA does not review individual installations of mtds but sets a credit for a specific mtd ([see protocol below](#Protocol_for_determining_credits)) that can be applied for all installations of the device, assuming proper design, construction, operation, and maintenance of the device. See the page [TP and TSS credits and guidance for manufactured treatment devices (mtds)](https://stormwater.pca.state.mn.us/index.php?title=TP_and_TSS_credits_and_guidance_for_manufactured_treatment_devices_(mtds)) for additional information. The credits determined by the MPCA define what is acceptable to the MPCA for meeting NPDES permit requirements. Local units of government may set different credits and requirements for mtds. These may be acceptable to the MPCA if they are as stringent or more stringent than what is established by the MPCA.

**Protocol for determining credits**

1. Only Washington State Technology Assessment Protocol – Ecology (TAPE)-approved devices receiving General Use Level Designation (GULD) certification for the following are eligible for credits. For more information, see [Washington State TAPE guidance and technical assistance](https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies).
   1. Basic treatment for TSS credit
   2. Phosphorus treatment for total phosphorus credit
2. TSS and TP credits may be determined, at the discretion of the Minnesota Pollution Control Agency (MPCA), for any device meeting criteria 1 above and that follows TAPE monitoring protocol or monitoring protocol [described here](https://stormwater.pca.state.mn.us/index.php?title=TP_and_TSS_credits_and_guidance_for_manufactured_treatment_devices_(mtds)#Protocol_for_monitoring).
3. TSS credit is determined as follows:
   1. The lower 95% confidence limit (LCL) for all samples from TAPE monitoring, calculated using [Washington TAPE’s Bootstrap Calculator](https://www.wastormwatercenter.org/wp-content/uploads/tape-bootstrap-ci-calculator-2011-08.xls) or
   2. the LCL for all samples from other monitoring that follows monitoring protocol [described here](https://stormwater.pca.state.mn.us/index.php?title=TP_and_TSS_credits_and_guidance_for_manufactured_treatment_devices_(mtds)#Protocol_for_monitoring), calculated using Washington TAPE’s Bootstrap Calculator.
   3. If the LCL is less than 80%, MPCA staff may assign a value of 80% if additional analysis and review indicates the device is likely to achieve 80% TSS removal under most storm runoff conditions. Factors considered in this determination include but are not limited to low influent TSS concentrations during monitoring, exceptionally small particle size in monitoring runoff, or laboratory analysis under conditions considered more representative of runoff than conditions that existed during field monitoring.
4. TP credits are determined as follows:
   1. TP credits may be determined, at the discretion of the MPCA, if the monitoring data used to calculate the credit meet the following conditions. Note: these analyses will be performed by MPCA staff.
      1. Median particle size must be 60 microns or smaller or analysis of TP removal of the mtd device must be performed on the fraction that is 60 microns or smaller.
      2. Regression analysis must be performed using the equation ***Measured TP removal = a + b\*predicted TP removal*** and the resulting p-value of the regression must be 0.05 or less. Predicted TP removal (TPR) is given by the equation TPR=[(PPF∗TSSR) + (DPF\*DPR)] where PPF is the fraction of TP in particulate form, TSSR is the removal percent for TSS, DPF is the fraction of TP in dissolved form, and DPR is the removal percent for dissolved phosphorus. Unless otherwise specified, DPR is assumed to be 0. In assessing the results of this analysis, the slope (b) should approximate 1. Note this regression may not be suitable if the device removes DP. See Appendix 1 for an example calculation.
   2. Tiered credits for TP are determined as follows.
      1. The Tier 1 TP credit equals 50%
      2. The Tier 2 TP credit equals the lower of three values: i) the lower 95% confidence limit (LCL) for samples with influent concentrations between 0.1 and 0.5 mg/L, calculated using Washington TAPE’s Bootstrap Calculator, or ii) the lower 95% confidence limit for samples with influent concentrations between the 5th percentile TP concentration, [as defined in the Minnesota Stormwater Manual](https://stormwater.pca.state.mn.us/index.php?title=TP_and_TSS_credits_and_guidance_for_manufactured_treatment_devices_(mtds)#TP_and_TSS_credits), calculated using Washington TAPE’s Bootstrap Calculator, or iii) TP removal calculated using the equation TPR=(PPF∗TSSR) = (0.75∗TSSR) where PPF is the fraction of TP in particulate form, assumed to be 0.75 (75 percent) and TSSR is the 95% LCL for TSS defined in item 3 above. The Tier 2 TP credit cannot exceed 60%. If values calculated using the above methods is less than 50%, no Tier 2 credit is given.
      3. A Tier 3 TP credit may be based on any of the following.
         1. If it exceeds 60%, the lower of a) the two LCLs calculated in item 4.b.ii or b) TP removal using the LCL for TSS, a PP:TP ratio of 0.75, and calculated by multiplying the TSS removal percent by the PP:TP ratio, plus specific design, construction, operation, maintenance, and assessment requirements described for the mtd device in the Minnesota Stormwater Manual. See the applicable mtd in [this section of the manual](https://stormwater.pca.state.mn.us/index.php?title=TP_and_TSS_credits_and_guidance_for_manufactured_treatment_devices_(mtds)#Derivation_of_TP_and_TSS_credits_for_specific_mtds).
         2. Up to a 10% credit for dissolved phosphorus (DP) removal in addition to the Tier 2 credit if the device has an MPCA-approved mechanism for permanently retaining dissolved phosphorus other than volume retention. The MPCA retains discretion at removal values for a specific device for DP based on available data.
         3. A TP credit of 100% for runoff permanently retained by the device plus the Tier 2 credit for runoff not retained. See Appendix 1 for an example calculation. At this time, the only volume retention mechanism credited is infiltration into the underlying subsoil. Infiltration must be calculated as an average annual volume infiltrated using a method approved by the MPCA.
5. Analysis methods
   1. TAPE’s Bootstrap calculator is used to calculate lower confidence limits
   2. A value of half (1/2) the reporting limit is substituted for non-detections
   3. Additional statistical analysis may be performed at the discretion of the MPCA. The MPCA does not have an established data analysis protocol but will define the methods used in its data analysis when conducting additional analysis for a device. Examples of additional analysis include the following.
      1. Identifying outliers. An example calculation would be any data point that is more than 1.5 interquartile ranges (IQRs) below the 1st quartile, and 1.5 interquartile ranges above the 3rd quartile.
      2. Group comparisons. An example would be comparing removal efficiencies of a device for TP inflow concentrations less than 0.1 mg/L with removal for TP inflow concentrations greater than 0.1 mg/L. MPCA will typically use nonparametric methods (e.g., ranks) for this type of analysis.

**Appendix 1 – Example calculations**

1. TP calculation if an mtd retains runoff volume. The credit is given by

Tier 3 credit = (Fraction of annual volume retained X 100) + (fraction of volume not retained X Tier 2 credit)

Example: A device retains 20% of the annual runoff volume and has a Tier 2 credit of 58%.

TP credit = (0.2\*100) + (0.8\*58) = 66% = Tier 3 credit

1. Removal efficiency = (Influent concentration - Effluent concentration)/Influent concentration \* 100.

Example: Influent concentration = 0.18 mg/L; effluent concentration = 0.067 mg/L

Removal efficiency = (0.18 – 0.067)/0.18 \* 100 = 62.8%

1. Predicted vs. measured TP removal

Assume the following dataset. Predicted TP removal = TSS \* PP:TP ratio. The regression is TP removal = a + b\*Predicted TP removal. The regression yields a p-value of 0.000017 with a slope of 1.24 (R2 = 0.63; intercept = -32.7). Assuming the intercept (a) is 0, the p-value is 10-13 with a slope of 0.82. The plot is shown below the table. The data meet the criteria of the p-value being less than 0.05. The correlation coefficient of 0.63 indicates about 2/3 of the variability in the data is explained by the model. The slope of 1.24 and the negative intercept indicate the device is over-performing compared to model predictions. This may be due to the use of ½ the reporting limit for most of the DP data and/or to the device removing DP.

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| **TP removal (%)** | **TSS removal (%)** | **PP:TP ratio** | **Predicted TP removal (%)** |
| 29 | 72 | 0.67 | 48 |
| 28 | 75 | 0.75 | 56 |
| 44 | 77 | 0.75 | 58 |
| 26 | 66 | 0.80 | 53 |
| 59 | 94 | 0.83 | 78 |
| 23 | 88 | 0.67 | 59 |
| 54 | 82 | 0.86 | 70 |
| 60 | 77 | 0.75 | 58 |
| 33 | 91 | 0.88 | 80 |
| 67 | 95 | 0.89 | 84 |
| 72 | 94 | 0.89 | 84 |
| 46 | 90 | 0.91 | 82 |
| 68 | 91 | 0.92 | 84 |
| 75 | 89 | 0.92 | 82 |
| 83 | 97 | 0.93 | 91 |
| 88 | 97 | 0.94 | 91 |
| 71 | 94 | 0.94 | 89 |
| 95 | 94 | 0.96 | 90 |
| 69 | 66 | 0.97 | 64 |
| 82 | 95 | 0.97 | 92 |
| 90 | 86 | 0.98 | 84 |

Table 1: Example dataset used for illustrating the relationship between measured and predicted TO removal.

Figure 1: Predicted TP removal = measured(TSS \* PP:TP ratio). The regression yields a p-value of 0.000017 with a slope of 1.24 (R2 = 0.63; intercept = -32.7). Assuming the intercept (a) is 0, the p-value is 10-13 with a slope of 0.82.

**Appendix 2 - Definitions**

* Dissolved phosphorus (DP) - phosphorus that remains in water after that water has been filtered to remove particulate matter, typically identified as phosphorus passing through a 0.45-micron filter
* Effluent concentration (Ce) - the concentration of a chemical in stormwater runoff exiting an mtd device following treatment by the device
* Influent concentration (Ci) – the concentration of a chemical in stormwater runoff entering an mtd device prior to treatment by the device
* Measured TP removal – the measured amount of TP removed by an mtd device
* Particulate phosphorus (PP) - phosphorus attached to solids (mineral and organic), typically identified as phosphorus retained by a 0.45-micron filter
* Predicted TP removal (TPR) – the amount of phosphorus predicted to be retained by a device based on the equation TPR=[(PPF∗TSSR) + (DPF\*DPR)] where PPF is the fraction of TP in particulate form, TSSR is the removal percent for TSS, DPF is the fraction of TP in dissolved form, and DPR is the removal percent for dissolved phosphorus. Unless otherwise specified, is DPR assumed to be 0.
* Removal efficiency – the percentage of a chemical retained (removed) by an mtd device, calculated as (Ci - Ce)/ Ci\*100
* Total phosphorus (TP) – the sum of particulate and dissolved phosphorus
* Total suspended solids - small solid particles which remain in suspension in water as a colloid or due to the motion of the water, suspended solids can be removed by the sedimentation because of their comparatively large size.